ABSTRACT

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In the last two decades, there has been significant improvements in pile design methods. These methods include variables that have been studied using laboratory and full-scale experiments. Refined understanding of the underlying mechanisms controlling pile response to loading enables introduction of variables in the design equations that reflect observations made in high-quality experimental data.

The mechanisms involved in the mobilization of the pile resistance (both base and shaft resistance) are studied in this thesis using a large-scale model pile testing facility consisting of a half-cylindrical calibration chamber with image analysis capabilities, instrumented model piles, and data and digital image acquisition systems. The thesis focuses on the effect of the pile surface roughness on the mobilization of tensile shaft resistance, the effect of the pile base geometry on the mobilization of base resistance, the analysis of possible mechanisms responsible for time-dependent increases in pile axial capacity, and particle crushing produced by pile installation.

A set of model pile tests were performed to study the effects of three different surface roughnesses on the shaft resistance of model piles jacked in the half-cylindrical calibration chamber. Digital images of the model piles and surrounding sand captured during tensile static loading were analyzed using the digital image correlation (DIC) technique. The base and shaft resistance measured for the instrumented model piles and the displacement and strain fields obtained with the DIC technique show that an increase in the roughness of the pile shaft results in

an increase in the average unit shaft resistance and in the displacements and strains in the sand next to the shaft of the pile. Guidance is provided for consideration of pile shaft surface roughness in the calculation of the tensile limit unit shaft resistance of jacked piles in sand.

Base geometry effects were studied using jacked and pre-installed model piles with flat and conical bases tested in the DIC calibration chamber. The results show that the mobilized base resistance of a model pile with a conical tip was less than that of an equal pile with a flat base, all other things being equal, by a factor ranging from 0.64 to 0.84. The displacement and strain fields obtained with DIC also show that the slip pattern below the pile with a conical base differs from that of a pile with a flat base.

Finally, the degree of crushing of silica sand particles below the base of model piles jacked in sand samples is studied. The particle size distribution curves are obtained before and after pile installation. Relationships between the load mobilized at the base of the model piles and two well-known breakage parameters are proposed. This work also provides detailed measurements of the trajectories followed by crushed and uncrushed particles during pile installation, and characterizes the typical particle crushing modes produced by piles jacked in silica sand.